Beard (Geo. M.)

ATMOSPHERIC ELECTRICITY AND OZONE:

THEIR RELATION TO HEALTH AND DISEASE.

BY

GEORGE M. BEARD, M. D.

[*REPRINTED FROM THE POPULAR SCIENCE MONTHLY, FEBRUARY,* 1874.]

NEW YORK:
D. APPLETON AND COMPANY,
549 & 551 BROADWAY.
1874.

ATMOSPHERIC ELECTRICITY AND OZONE: THEIR RELATION TO HEALTH AND DISEASE.[1]

AMONG the published list of questions at the civil service examination of the Board of Health of New York last summer I observed this: "What is the composition of pure air?"

As I laid down the paper I asked myself this question, or, rather, I put to myself the same question in another form: "Is there among the sons of men any one who really knows the composition of pure air?"

Still further I queried with myself what answer I should have given to the question had I been one of the applicants for a position on the Board of Health, and it seemed to me that, after stating what almost every school-girl knows about the relative proportions of oxygen and nitrogen, I should have added this codicil: "The question of the composition of pure air is one that is too complicated to admit of an answer." What I have to say this morning on atmospheric electricity and ozone will serve, so far as it goes, to enforce this view.

How the Subject of Atmospheric Electricity and Ozone has been investigated.—During the past quarter of a century regular daily observations of atmospheric electricity have been made in Brussels, Munich, and for the past ten or fifteen years in St. Louis. The difficulties in the study of the subject are very great, but, from the accumulated observations of the different investigators, some few interesting and important general facts have been secured.

Apparatus for studying Atmospheric Electricity; Measuring Apparatus.—Prof. Dellman, of Kreuznach on the Rhine, for several years made three regular observations each day of the atmospheric electri-

[1] Read before the American Public Health Association, in New York, November 13, 1873. It was voted by the Society to publish this paper in their "Transactions," but, through the courtesy of the Secretary, the author is allowed to publish it independently.

city. The electrometer that he used in these observations is a torsion balance. A small thread of glass going vertically through a glass tube has on its lower extremity a small needle of brass fastened to it. This light brass needle, when influenced by any force, can move over a metallic disk with a graduated scale. Below this light brass needle is another light brass needle, which is fixed and isolated from the metallic disk, and connected with a metallic wire which receives the electrical charge from outside. By means of a micrometer screw the upper needle can be lowered and raised so as to touch the lower needle, or be kept above it.

The whole instrument rests on three iron legs, which can be screwed up and down so as to give it the level required. When the wire outside receives a charge of electricity, it communicates this charge to the lower needle. If, now, the upper needle be lowered and brought in contact with the lower one, it also receives a charge of electricity. But, as like electricities repel each other, the other needle will be at once driven off over the graduated scale. The number of degrees that it is driven will depend on the strength of the charge. To determine whether the electricity is positive or negative, subsequently charge the wire with electricity of known quality. If they are alike—that is, if the first charge be of the same quality as the second—the needle will be repelled still farther; if unlike, the needle will return toward the fixed needle.

Collecting Apparatus.—Dellman's apparatus for collecting atmospheric electricity is a hollow brass or copper ball about six inches in diameter, with a stem of metal. The metallic stem rests in a metallic tube, but is isolated from the tube by shellac. This apparatus is attached to a pole almost thirty feet long. This pole is drawn by a windlass up the walls of a house to the top of the roof. The operator then touches the stem of the ball with a piece of brass in the shape of a half-moon. This charges the ball with electricity. The pole is now let down at once, and the collecting apparatus is brought in control with the measuring apparatus. The electricity which is thus collected in the ball is developed in it by induction. The natural electricity of the ball is separated by the surrounding atmospheric electricity into positive and negative electricity. One of these goes to the lower part of the ball, the other remains in the upper part. Atmospheric electricity is usually positive. The natural electricity of the ball being decomposed, the negative is attracted to the upper and the positive to the lower part. When the operator touches the stem of the ball with the piece of brass, the positive electricity is conducted through his body to the ground, and the negative remains in the ball.

When, therefore, the electrometer shows negative electricity, it indicates positive electricity in the atmosphere, and vice versa.

It has been shown that there are two daily tides of positive atmospheric electricity—the high tides between 9 and 12 A. M. and be-

tween 6 and 9 P. M.; the low tides between 2 and 5 P. M. and 1 and 5 A. M. The annual variations are fully as marked as the diurnal; the quantity of positive atmospheric electricity being greatest in the winter, least in the summer. Dr. Wislizenus found that, in 2,124 observations made at regular hours, the atmospheric electricity was 2,046 times positive and but 78 times negative. Of the 78 times, 30 were connected with thunder or hail storms, or by thunder and lightning, 23 by common rains, and 20 by high winds and gales without rain, thunder, or lightning, 4 by snow, and 1 by fog.[1]

According to Herschel, out of 10,500 observations at the Royal Observatory, only 364 showed negative electricity. The remainder, 10,176, all showed positive electricity. Negative electricity was usually attended with rain.

It seems, therefore, that the chief cause of a condition of negative atmospheric electricity is storm, and especially thunder-storms, and that at all other times positive atmospheric electricity prevails. In very many cases this change to negative electricity takes place shortly before the storm approaches; during its progress there may be—especially in thunder-storms—rapidly-repeated alternations of positive and negative conditions, followed by an equilibrium, or by positive electricity.

Dr. Wislizenus, of St. Louis, also found that snow-storms and fog were usually accompanied by an increase of positive electricity; this observation is of interest, because it accords with the fact that the approach of snow-storms and the presence of simple fog do not cause the exacerbations of rheumatic and neuralgic pains that are experienced on the approach of storms of rain, or thunder and lightning.

Ozone-History.—From the earliest recorded ages a peculiar odor has been observed during thunder-storms and other electrical disturbances, and especially in connection with flashes of lightning. The peculiar odor of thunder-bolts has been referred to by Homer, both in the "Iliad" and the "Odyssey." Jupiter is said to strike a ship with a thunder-bolt, "ἐν δὲ θέειου πλῆτο," full of sulphurous odor, and to hurl a bolt into the ground "with the flame of burning sulphur." This peculiar sulphurous odor has been observed not only during thunder-storms, but also, it is said, during displays of northern and southern auroræ.

So long ago as 1785, Van Marum, of Holland, observed that electric sparks passed through oxygen gas (that had been discovered by Priestley only eleven years before) gave rise to a peculiar sulphurous or electrical odor; and, at the beginning of the present century, Cavallo, a prominent name in the history of electricity, called attention to the fact that this "electrified air," as it was termed, had an antiseptic effect on decomposing matter, and was a salutary application

[1] Dr. A. Wislizenus, in Transactions of St. Louis Academy of Medicine.

for fetid ulcers. In 1826 Dr. John Davy, in a measure anticipating Schönbein, recognized this peculiarity of the atmosphere, and devised tests for detecting it.

The real scientific history of ozone dates from 1839, when Prof. Schönbein, of Basle, the renowned inventor of gun-cotton, observed that the electrolytic decomposition of water was attended by a peculiar odor resembling that evolved during the working of a frictional electric machine. In 1840 Schönbein called the attention of the scientific world to the newly-discovered substance, to which he gave the name of *ozone*, from the Greek *ὄζω*, to emit an odor. He showed that this odor appeared at the positive pole during the electrolysis of water. He furthermore pointed out that ozone may be produced by the slow oxidation of phosphorus in moist air or oxygen, and that the odor was similar to that which is observed during flashes of lightning. Schönbein studied hard on the subject for many years, and arrived at the conclusion that oxygen is capable of division into a negatively polar state, ozone, and a positively polar state, which he called *antozone.* During the past quarter of a century the subject of ozone has been studied by some of the most eminent scientists of the age, among whom we may mention the names of Berzelius, De la Rive, Marignac, Becquerel, Faraday, Fremy, Meissner, Houzeau, Scoutteten, Odling, Andrews, Tait, Fox, Fischer, Boeckel, Zeuger, Moffat, Nasse, Engler, Erdmann, Angus Smith, Poey, A. Mitchell, Soret, Baumert, Williamson, and very many others.

The Nature of Ozone and Antozone.—The result of this quarter of a century of research is the present conclusion that ozone is *condensed allotropic oxygen.*[1] In regard to antozone there is much difference of opinion among scientists. There are those who declare that it is a myth. The original hypothesis has recently been losing its hold on the scientific mind, and further researches are necessary to determine what it is and what it is not. The present opinion of the German philosophers is, that antozone is the *peroxide of hydrogen diffused through the air.*

Preparation of Ozone.—Ozone is prepared in various ways—by passing electric sparks, or electricity without sparks, through oxygen or air, by the electrolysis of acidulated water, by oxidizing phosphorus in moist air, by the action of strong sulphuric acid (three parts) on permanganate of potash (two parts), by sending water in the form of spray through air, by introducing hot glass rods into vessels filled with the vapor of ether, and by the slow oxidation of ethers and oils, etc., when exposed to light.

Properties of Ozone.—Ozone is a colorless gas, with a powerful and peculiar odor. Like oxygen, it is an oxidizing agent of great power. It changes indigo into *isatin*, the black sulphate of lead into the white

[1] "Ozone and Antozone: their History and Nature." By Cornelius B. Fox, M. D. London, 1873.

sulphate of lead. It oxidizes antimony, manganese, arsenic, iron, zinc, tin, silver, lead, bismuth, and mercury. Many of the lower oxides it transforms into peroxides. It corrodes India-rubber and decolorizes blue litmus-paper. It acts with great rapidity on iodide of potassium, liberating the iodine. It quickly consumes ammonia, changing it into nitrate. It decomposes *hydrochloric* acid, liberating the chlorine. It is insoluble in acids, alkalies, alcohol, ether, the essential oils, and water. The odor of ozone is very penetrating; air containing but one millionth of it is said to be perceptible to the olfactories. The peculiar odor of sea-air is in part the result of ozone. All air, even the purest, has more or less ozone; but so accustomed do we become to it that it is only by sudden change into it that we perceive it. Visitors at the Mammoth Cave, Kentucky, report that, on emerging, the air has a peculiar and vivid odor such as they never before realized. That we can in a half-hour become so used to the foul air of a closed room that we do not perceive its odor until we leave it for a few moments and then return to it, is the experience of every one. The peculiar odor of ozone can be obtained very easily indeed by touching a metallic electrode of a galvanic battery of a number of cells against one of the plates of the batteries so as to make a connection of the current, or by touching the metallic ends of the poles for a moment with the spark thus produced.

Ozone in the Atmosphere.—Ozone, like electricity, exists normally in the atmosphere, but varies in amount in different localities at different seasons and in different hours of the day, and is considerably dependent on various meteorological conditions.

It varies with the Locality.—It is more abundant in the country than in the city; by the sea-side than inland; among mountains than in valleys; in well-drained neighborhoods than in those where such sanitary provisions are disregarded. The opposite results of different observations in different localities are accounted for in part by the fact that the amount of ozone is not everywhere constant. Ozone is not often found in closed rooms or chambers. Those who stay in-doors are deprived both of atmospheric electricity and ozone. Like electricity, it increases with the altitude; hence we may in part explain the beneficial effects of mountain-air. The air of the sea is richer in ozone than the air of the land, because evaporation is attended with the simultaneous development of oxygen and ozone. Hence it is that tests applied over the surface of the sea or of lakes, ponds or rivers, show a deeper tint than tests applied over the land. An excess of sea-air will blight vegetation in the vicinity of the ocean; delicate fruits, as the peach and the plum, are cultivated only with difficulty. It has been observed that a prolonged storm coming from the sea will blight vegetation. Possibly the excess of ozone may be a factor in this destruction.

It varies with the Season.—Ozone, like electricity, is more abundant in the winter than in the summer. Atmospheric ozone is not measured

with the same accuracy as atmospheric electricity, and therefore the regular gradations during the spring and autumn have not been established as in the case of the latter agent. For the same reason there is much discrepancy among different observers. It is believed that the relatively small amount of ozone in the summer and early fall is due partly to the fact that it is consumed in oxidizing the impurities of the air, and partly to the fact that there is less atmospheric electricity at that time.

It varies with the Hour of the Day.—There is considerable difference in the conclusion of different observations, but the average results seem to show rather more ozone in the atmosphere during the night than during the day. Like atmospheric electricity, ozone rises and falls in pretty regular tides twice during the twenty-four hours. The maximum periods are between 4 and 9 A. M. and 7 to 9 P. M. The minimum periods are between 10 A. M. and 1 P. M. and between 10 P. M. and midnight. It will be seen that ozone is at its minimum when the sun is at the zenith, and its maximum about sunrise and sunset. It varies with atmospheric conditions, as electricity, rain, fog, thunder-storms, snow, wind, clouds, halos, and auroras, eclipses, etc. There is a certain correspondence between the tides of electricity and of ozone; they seem to rise and fall together. This will be apparent on comparing the statements made above. A comparison between atmospheric ozone and electricity has been made by Quetelet, who has given the subject special attention. His observations, which were made with Peltier's electrometer in August, 1842, are represented in the following table:

Hours.	Electricity.		Ozone.	
6 A. M.	+17		4.10	
7 "	27	Maximum.	4.60	Maximum.
8 "	36		4.88	
9 "	27		4.45	
10 "	20		.31	Minimum.
11 "	14		.41	
12 M.	12		.80	
1 P. M.	10	Minimum.	.96	
2 "	5		1.17	
3 "	3		1.31	
4 "	5		1.40	
5 "	11		1.33	
6 "	18		1.33	
7 "	24		1.41	Maximum.
8 "	30	Maximum.	1.56	
9 "	32		1.70	
10 "	30		1.00	
11 "	19		1.15	

Ozone, like electricity, seems to depend in a measure on the humidity of the air. The relation of fog to atmospheric ozone is not yet determined, but it seems to be agreed that during snow-storms it is increased. Thus, Wolf gives the following comparison:

Amount of atmospheric ozone in fine days, 4.186.

Amount of atmospheric ozone in rainy days, 11.40.

Amount of atmospheric ozone in snowy days, 14.15.

It will be remarked that snow-storms also favor atmospheric electricity. The direction of the wind has a certain influence, as is well recognized, on ozone. According to Lowe, ozone is most abundant during a southwest or south-southwest wind, and least abundant when the wind is north or northeast. There is a maximum when the barometer is low, and a minimum when it is high. Other inland observers agree with Mr. Lowe. At the sea-side, winds blowing from the sea bring with them abundant ozone.

When the sky is darkened with clouds, there is more ozone than when it is clear. Before thunder-storms, or while they are at a distance, ozone, like electricity, increases, and various changes and fluctuations may occur during the progress of the storm.

Summing up in a few words, we may say that atmospheric ozone is more abundant during the winter and spring, because in those seasons there is much rain, snow, hail, and wind, a low temperature, and a maximum of electricity. During these seasons, also, there is little decomposition going on in the vegetable world. In the summer and autumn, atmospheric ozone is least abundant, because, during these seasons, there is no snow, or hail, less wind, rain, high temperature, a minimum of electricity, and a great amount of decomposition of animal and vegetable matter, by which the air becomes polluted, and is neutralizing and purifying while the ozone is consumed.

Average Quantity of Ozone in the Atmosphere.—The quantity of ozone in the atmosphere is exceedingly minute. The proportion varies with the locality, the season, the hour, etc., as we have already seen, and it also varies with the altitude, for it is with this agent as with electricity—it increases as we rise above the earth. According to Houzeau, air of the country, about six feet above the earth, contains about $\frac{1}{450000}$ of its weight of ozone, or $\frac{1}{700000}$ of its volume. The quantity is so minute that it may probably be increased several fold without perceptible injury to man or animals.

Origin of Atmospheric Electricity and Ozone.—The sources of ozone in the atmosphere are almost innumerable. Like atmospheric electricity, it results from a wide variety of countless and ever-changing influences; it is one of the grand resultants of the ceaseless chemistry of the earth and sky. The evidence is now pretty clear that one prominent source of atmospheric ozone is in vegetable life. The oxygen that plants evolve from their leaves is more or less ozonized. It is claimed that ozone is developed with the perfume of flowers. The most odorous flowers, as the heliotrope, hyacinth, and mignonette, are the most prolific generators of ozone. This ozonic property of flowers is most manifest under the direct influence of sunlight. Lavender, fennel, mint, clove, and cherry-laurel, evolve ozone with special abundance when exposed to the solar rays. It is believed that the oxida-

tion of essential oils, as anise-seed, bergamot, etc., under exposure to the light and air, develops ozone, and that in all flowers the source of the ozone is the essence; hence it is that the most odorous are the most ozoniferous.

If we accept these conclusions, we must also concede that the custom, now almost forgotten, among physicians, of providing the handles of their canes with vinaigrettes, with the fancy that the fumes would protect them against infectious disease, has a certain scientific basis. The aroma of snuff is said to develop ozone, and for years snuff has been regarded as a disinfectant.

Electricity, as is well understood, is generated by any kind of chemical change or action. Even friction and pressure cause electricity to be evolved, as was shown by Armstrong's experiments with jets of condensed air, liberated under high pressure. It was shown by Faraday that the friction of water dropping against bodies gives rise to electricity, and it is probable that the same effect follows the friction of water against air.

Volta showed, nearly a century ago, that the spray of a fountain furnishes negative electricity. Trolles, and afterward Humboldt, observed that a cascade or water-fall filled the air for some distance with negative electricity, and Bell thinks he has proved that a cascade is negative at the top, and positive at the bottom; that the positive electricity passes into the earth, leaving the negative in the spray.

We are then to look for the sources of ozone, as of electricity, in all the infinite play of the terrestrial powers: in the falling away of the rocks, and the springing forth of plants; in the oxidation of metals, and the emission of the perfume of flowers; in the deposition of dew, in the falling rain, the rattling hail, and the drifting snow; in the rushing of the wind, and the conflict of the storm; in the friction of the clouds as they pass in the sky, or rest on the summits of the mountains; in the ceaseless evaporation on sea and on land; in the rushing torrents of the hills and the dashing breakers on the shore.[1]

Ozone a Disinfectant.—The disinfecting powers of ozone have long been noted. It is one of Nature's great purifiers. It is sometimes generated artificially in hospitals and public buildings. It acts both on animal and vegetable matter. According to Schönbein, air containing but $\frac{1}{3240000}$ of ozone is capable of disinfecting its own volume of air filled with the effluvia, evolved in one minute, from four ounces of highly-putrid flesh.

Ozone, in disinfecting and purifying decaying and putrid matter, is itself destroyed. It dies, that others may live. Hence it is that there is so little of ozone in the air of towns and cities and villages, and in hospitals. The ozone is consumed in the process of oxidizing the products of combustion and decay.

[1] *Vide* Fox, above quoted.

Dr. Richardson has noticed that oxygen, that has been repeatedly passed over decomposing animal matter, loses its power of oxidation.

Physiological Effects of Ozone.—The physiological effects of ozone have been studied both on man and on animals. It is believed that the bracing and inspiring effect of a clear, crisp, and sparkling morning, is due in part to the great amount of ozone in the atmosphere. When it is held in combination with oxygen or common air, it acts much like oxygen, but more powerfully. It affects the pulse, the respiration, and the circulation, in various ways, according to the quantity taken, and the temperament of the individual. In this respect, it behaves like electricity. It has been thought that ozone is formed in the body from the contact of oxygen gas with the blood, and there are those who believe that it is absorbed with the ozone in the air, and is carried into the blood, where it takes part in the process of oxidation.

There is a possibility, if not indeed a probability, that electricity, in its passage through the body, generates ozone in very minute quantities, through the electrolytic and other changes that it produces, and the theory, that the beneficial effects of electrization are in part due to the ozone thus generated, has some plausibility. But on all these subjects very little is known. Experiments made in the laboratory with ozone, artificially prepared, are highly suggestive. Catarrhal symptoms and attacks, much resembling epidemic influenza, are produced by long breathing air laden with ozone. It is stated that it would be difficult to distinguish between the symptoms of influenza and the symptoms of an over-dose of ozone. Experiments on animals have shown that irritation of the mucous lining of the throat and nostrils, with febrile symptoms and congestion of the lungs, may be quickly excited by breathing air containing a large percentage of ozone. If animals are, for a long time, subjected to ozone, they perish. In their susceptibility to it, however, they vary widely. A rabbit, breathing air mingled with $\frac{1}{2000}$ of its weight in ozone, has died in two hours. Mice, breathing air about $\frac{1}{6000}$ of ozone, have died immediately. Rats are more susceptible than Guinea-pigs, and Guinea-pigs are more susceptible than rabbits. Pigeons are quite tolerant of ozone, and frogs are proof against it, provided they have abundance of water. Birds are specially tolerant of this agent, as might naturally be inferred, since, in the higher strata of the air, where they fly, ozone is more abundant than near the earth.

It has been stated that there is a relation between ozone and intermittent and remittent fevers; that rheumatism is prevalent when ozone is deficient; that, when ozone is in excess, diphtheria, quinsy, small-pox, herpes, measles, scarlatina, and other cutaneous affections, prevail; and that, during the visitation of the cattle-plague in England, ozone was below the usual standard.

There is considerable more of evidence to show that visitations of cholera are accompanied with a diminution in the atmospheric ozone.

Experiments have shown that germs, sporules, bacteria, vibriones, and small monads, with other low forms of life, are destroyed by ozone. On the accepted view that epidemic and infectious diseases are caused by spores, bacteria, etc., we can understand how a deficiency of ozone in the air may invite disease.

The only conclusions on this subject of the relation of atmospheric ozone to disease, that at present seem justifiable, are these:

1. A deficiency of ozone in the air probably has a certain relation to epidemic and chronic disease.

2. Deficiency of ozone invites disease, by debilitating the system, and thus making it less capable of contending with morbid influences.

Tests for Ozone.—Of the various tests for ozone, those which are most used are starch and *iodide of potassium.* Fox prefers the *iodized litmus* and the simple *iodide of potassium* test. The litmus-paper and the iodide of potassium must both be pure. The Swedish filtering-paper is the best. Blue litmus is purified by boiling, etc., until it is of a vinous red color. The strips of filter-paper are plunged for *one-third* of their length into a solution of neutral iodide of potassium, made by dissolving 15½ grains in 321 grains of distilled water.

These tests are exposed to the air for twelve or twenty-four hours beneath a plate. If ozone be present in the air, the iodized part becomes blue, and the non-iodized part is unchanged. Sometimes the test-paper is placed in ozone-boxes, so constructed that a current of air passes through them.

The practical bearings of atmospheric electricity and ozone are manifold:

1. Many nervous and other diseases and very many nervous sensations are perceptibly affected by changes in the quantity of electricity and ozone. Making the necessary concession that the subject of the relation of atmosphere to health is one of many complications, still we are now in a position to claim with considerable positiveness that a part of the benefit or injury that is derived from change of climate, or from the various atmospheric changes, is the result of variations in the amount of ozone and electricity. After eliminating the factors of heat and cold, which are the most obvious and best understood of all atmospheric qualities; of moisture and dryness, the potency of which is everywhere recognized; of carbonic and nitric acid; of oxygen pure and simple, there remains much that only ozone and electricity can well account for.

2. Not a few sensitive and impressible organizations experience variations of strength and debility, of vigor and *malaise*, that very well correspond to the variations in atmospheric electricity, or ozone, or both. There are thousands of people who are at their maximum of strength in the cold months of winter, who begin to decline in the spring, who, in the summer, are at their minimum, and who regularly rally during the autumn. There are those who, almost every

day, pass through tides of feeling, which, if they do not mathematically correspond to the daily tides of ozone and electricity in the air, do certainly follow so closely as to make us suspect, to say the least, a certain relation between the variable states of the system and the variable states of the air. From 8 to 12 A. M. is the golden time for brain-work, as all students know; from 1 to 4 P. M. there are frequently a dullness and lassitude that make hard toil a task. Many—even those who take but a lunch in the middle of the day—are sleepy at this time, and, unless they are kept awake by business, are disposed to take a nap. The latter part of the afternoon the spirits revive, and between four and eight or nine o'clock is what might be called the silver period of the day for all mental labor. The night is given to sleep, but those who rise very early do not usually labor to so great advantage as those who defer their severest exertions until the forenoon. In these statements we but give the experience of the majority of brain-workers whose temperament is of the susceptible order, and who therefore appreciate the varying moods of the system.

The chief complication that enters into these calculations is the fact that there is least ozone and least electricity in the air when there is most heat, and that heat is of itself debilitating.

3. Irregular disturbances in the electrical condition of the atmosphere, in storms, and especially in thunder-storms, and, in our climate, northeast storms, unquestionably affect the nervous system of impressible temperaments unpleasantly, and bring on or aggravate neuralgic, rheumatic and other pains, as well as incite mental distress and discouragement.

This fact, concerning which some have been skeptical, is as demonstrable as any general fact of the kind can be, and the opportunities for testing it among the nervous patients in this country are exceptionally abundant. Sensitive patients are oftentimes prophets of the weather; without error they can predict, even twenty-four hours beforehand, an approaching northeast storm, and, before a rising thunder-squall, they are sometimes excessively miserable. There are those who are utterly prostrated before and during a thunder-storm, thrown into vomiting and convulsions; and these spasmodic disruptions are followed by hours or days of exhaustion.[1]

Now, it is just before thunder-storms that the atmospheric electricity is so apt to be negative, and during a thunder-storm the changes in the electrical condition are very rapid.

[1] These nervous perturbations, in their various degrees, have seemed to me to be sufficiently frequent and distinctive to entitle them to be regarded as a separate disease. To this disease I have given the name *Astraphobia*. A brief description of this disease, with cases and remarks, can be found in Beard & Rockwell's "Medical and Surgical Electricity," p. 604. Strictly speaking, it comes in the category of affections allied to hysteria, like *agoraphobia* that Westphal has described. Astraphobia is more common in women than in men, though I have seen it in both sexes. The tendency to the disease appears to run in famllies.

At the Sussex County Insane Asylum, in England, the chaplain of the institution made for several years a series of experiments which showed very clearly that attacks of epilepsy and mania correspond, in a very large number of instances, to changes in electrical and other conditions of the air, and he believes that electricity is the main factor.

There is nothing strange in all this, for all naturalists know that many plants predict storms with wonderful precision hours before they appear. Man, with his exalted and complex nervous system, and especially civilized man, is far more impressible than any animal or flower.

It is not wise nor scientific nor humane to despise these subtile, storm-anticipating pains from which our patients suffer. If these are not real, nothing is real, and all existence is a delusion and a sham. They are as truly realities as small-pox, or typhoid fever, or a broken leg, and should be considered accordingly. When, therefore, the *Danbury News* man dedicates his almanac to that distinguished collaborator and weather predicter, the inflammatory rheumatism, he is as scientific as he is funny.

4. The beneficial effects of sea and mountain air on invalids may be explained in part, if not largely, by the fact that there is more ozone in the sea-air than in the land-air, and more ozone and more electricity in high than in low altitudes.

In elevated regions the air is, of course, rarer than in low-lying regions, and the quantity of oxygen inhaled must, of necessity, be less than when the air is dense; but ozone and electricity both increase as we rise, and very likely this fact will explain the exhilaration and invigoration which not only consumptives but nervously exhausted patients experience on removing to the mountains. The benefit that consumptives find, by residence in elevated districts, is almost entirely of a general, stimulating tonic character, that could very well be explained by the ozone and electricity which they inhale far more abundantly than in the lowlands. The benefit derived from a change of residence from the city to the country may be, in part, similarly explained.

The influence of atmospheric electricity and ozone must always be taken into consideration in estimating the effects of medical treatment. Exacerbations of neuralgia, or rheumatic pain, or general *malaise*, or attacks of melancholia, or mania, may be excited by low atmospheric conditions, when, perchance, we suppose that the treatment we employ is working badly; and, conversely, the exhilaration that patients feel at various times should sometimes redound to the credit, not of the physician, but of the electricity or ozone in the air. There are days when all our patients seem to be depressed—all appear to be going down—and there are days when all appear to be doing well. We cannot be too cautious in attributing these changes to other factors besides the treatment we employ. We are justified in encouraging dis-

heartened patients, who are ready to perish, with the hope that, not unlikely, they may be suffering from low atmospheric conditions that will in time correct themselves.

In order to settle some of the questions raised in this paper, I would offer these four suggestions:

I. Let daily observations in atmospheric electricity and ozone be undertaken under the patronage of the governments of different countries at all meteorological and astronomical stations. These observations, carried on for a number of years, would help to answer many important queries, and, among others, whether there is more or less of atmospheric ozone in America than in Europe. The data derived from such comparative researches would help, perhaps, to explain the peculiar and unparalleled nervousness of the people of the United States. They might help to explain the extraordinarily stimulating character of the climate of California. They might help to explain the fact that, on the Pacific coast, sunstroke is not apt to occur, even under very high temperature; while, in the East, prostration from exposure to heat not very excessive is, almost every summer, a common affection.

II. Let comparative observations be made of the atmospheric electricity and ozone of low and elevated regions. The data derived from such observations might help to explain the great benefit that consumptives and nervous patients so often find by a residence among the mountains. They might help to explain the absolute relief or cure of autumnal catarrh or hay-fever that is found in regions lying all the way from five hundred to twenty-five hundred feet elevation above the level of the sea.[1] It has already been shown by the experiments of Becquerel on the plateau of St. Bernard, and by other observers, that there is more of atmospheric electricity as we rise above the earth, and the same has been proved also of ozone. If these results shall be confirmed by a larger induction, by observations among the Catskill and White Mountains, then we should have a potent and suggestive explanation, so far as it would go, of the powerful hygienic effect of mountain residence.

III. In times when certain epidemics are abroad, such as cholera, throat-distemper, scarlatina, etc., let observations made of the atmospheric ozone be compared with observations made at the same season and same place in other years. Of course, whatever the facts may be, we cannot rush to conclusions in this matter. If ozone be absent, may not its absence be due to the fact that it has all been con-

[1] Blakeley, in his work on "Hay Fever," has shown by experiments that more spores and pollen, by far, are found a thousand feet or so above the earth than at the ordinary breathing level. These experiments would indicate that the cure of this disease, by removel to elevated regions, must at least be explained in some other way than by the theory that the mountain air contains less irritating substances. This subject I hope to be able to investigate at the White Mountains during the coming summer.

sumed in deodorizing the impurities of the air, which impurities may be the cause of the epidemic?

IV. Let the physiological and therapeutic effects of ozone on the human system be studied by a large and copious induction from a wide variety of temperaments and diseases.

The criticisms that you will make on this paper I can easily foresee. You will say—and not unjustly—that in all these researches, and especially in those that relate to ozone, there is much of vagueness, little of precision—that an enormous margin yet remains wherein we may study or conjecture.

All this I admit freely and fully, but is it not so with the incipience of every science and of all forms of knowledge whatsoever? Shall we wait until our knowledge becomes absolute before we reveal it? Does it not rather become those of us who are seeking truth, as often as may be, to take account of stock of our discoveries? Is it not well, now and then, to take an inventory of our ignorance, and see how little we know? In this grand and long campaign against the kingdom of darkness we must forage on the enemy's country, and sustain ourselves for the toils of the future by the best we can get as we go along. I would be inspired by the words of Confucius: "What we know, to know that we know it; what we do not know, to know that we do not know it, that is knowledge." I would be inspired by the example of Lessing, who preferred to seek after truth, than to find it.